EUPALINOS
Surveying Software

HIGHLIGHTS

- Offers all the computations required for underground construction
- Administration of all relevant planning data
- User-friendly and clear menu structure
- Many data interfaces
- Numerous online functions for the control of total stations
- Extensive graphics functions

Field of Application

The EUPALINOS software package for the first time offers a high-performance tool for the solution of all geodetic tasks in the fields of tunnel construction and geotechnics. This software therefore constitutes a core component of our ITMS (Integrated Tunnel Monitoring System) which, in combination with a variety of hardware components, offers a total solution in the fields of tunnel surveying, monitoring, tunnelling heading control and geotechnics.

EUPALINOS has many functions for management and processing of project, measurement and point data and enables, via fully implemented data flow starting from registered observations, the fast and simple compilation of different analyses such as profile controls, geotechnical displacement diagrams, setting-out data, etc. The analyses, diagrams, protocols and calculations created in this way form the basis for tunnel heading surveys, control measurements and geotechnical interpretation of the rock mass behaviour. Integration of the wide range of functionalities in the system deserves special recognition. All the EUPALINOS functions are therefore available at all times, which significantly increases the flexibility of various applications.
Motor laser systems can therefore be directly utilised for online monitoring, if required. Analyses of profile checks, network extensions or control measurements can be performed directly at the control computer of a TBM guidance system.

**Description of services**

- Management of all necessary planning data, such as axes in the ground plan and vertical projection, standard cross sections, block partitioning plans, profile points, etc.
- Strict computation and control of axes, incl. graphic diagrams
- Management of trigonometric and levelling measurement data
- Management of reference, object and profile control points
- Administration of the heading chainages
- Analysis of tacheometric and levelling measurements
- Analysis of gyro measurements (Gyromat 2000)
- Net adjustment of planimetric and vertical control survey nets with extensive options for grid positioning and weighting
- Profile checks and cubature calculation
- Comprehensive graphical display options for the results of the 3D deformation measurement for geotechnical evaluation
- Online monitoring incl. alarm control (optional link to the KRONOS Tunnel Information System)
- Online profile control (together with the KRIOS Online Profiler)
- Fully automated free stationing for all online functions
- Online convergence measurement (for TBM drives)
- Fully automatic control of the GYROMAT 2000/Leica TPS gyro system
- Motor laser functions for tunnel drive control and pipe umbrella setting-out (see TALOS motor laser system)
- Various transformations and additional functions (e.g. for determining the loading of the shotcrete shell in accordance with the flow rate method through 3D displacement measurements)
- High performance setting-out functions (e.g. for the Atlas Copco DCS system)
- Online control of partial and full face boring machines (see TAUROS machine controls)
Program description

General

- Project-related data organisation
- Arrangement of all functions in clear menus
- Implementation of the functions via user-friendly dialogues
- Numerous ASCII interfaces for data input and output
- Management of all plan data (axes, standard cross sections etc.) and parameters
- Testing the plan data (axis elements) for consistency
- Visualisation of the plan data (profiles and axes)
- Checking of the axes data via integrated alignment calculations
- High performance functions for handling of standard cross sections (interpolation, profile offset, etc.)
- Preparation of all graphics (displacement diagrams, profile checks, etc.) via meta-files (→ placing on site networks or dispatch via e-mail) or in WMF or PDF format
- Easy and simple analysis of trigonometric and levelling observations
- Automatic allocation of point numbers during analysis to facilitate and speed up surveying work
- Analysis and graphical preparation of profile checks, including cubature calculations
- Extensive setting-out functions for excavation and inner shell (e.g. conventional laser cut-off, block gap calculation, 3D setting-out of profile related points)
- Analysis of geotechnical measurements with respect to time vs cross-section and tunnel advance

Data management

- Differentiated management of points in accordance with their purpose
- Extensive management functions for reference, object and profile control points
- ASCII data interfaces for input and output of large quantities of data
- 2D and 3D transformations
- Transfer of points from and to the total station for direct setting-out
Analysis

- Fully automatic analysis of tacheometric measurements and levelling by means of a special coding system
- Automatic allocation of point numbers (not necessary to enter the correct point numbers of the reference points)
- Differentiated treatment of position and/or fixed elevation points with respect to their accuracy, in the course of the analysis
- Determination of the locations through free stationing (1D, 2D or 3D)
- Analysis of complex geotechnical measuring arrangements with several instrument positions via strict compensation for position and elevation
- Graphical representation of observation configurations (network plots with error ellipses)
- Detailed record of the calculations
- Fully automated storage of the results in the database through allocation of corresponding measuring codes
- Powerful equalisation module for the calculation of position and/or elevation networks with automatic computation of approximation coordinates and error finding algorithms for correction of allocation errors (point number confusions, etc.)
- Extensive possibilities for net datum through transformation and “soft positioning” and differentiated weighting approaches
- Combination of trigonometric and levelling networks, incorporating gyroscope azimuths and plumbing, for strict net-adjustments of net sections above and below ground (shafts)

Tunnel heading control

- Profile recording manually (without reflector or with profiled disk), program controlled via total station or online via an industrialised control computer
- Strict orthogonal profile recording for expansion sections
- Use of arbitrary reference lines within a profile
- Automatic consideration of lay-by sections through profile interpolation
- Calculation of over- and under- excavation (cubatures)
- Graphical output via meta-plot files or PDF (for e-mail dispatch)
Geotechnical analyses

The coordinates of the observed object points are stored in the database immediately after the measurement data stream has been transferred and analysed, together with the tunnel heading chainage forming the basis of the geotechnical analysis. All analyses are performed without an intermediate step or data export, directly using the 3D points administered in the Eupalinos database. New analyses and changes in the database therefore have immediate effect in the graphical representation. Points which are queried (outliers) are not deleted, but only flagged and optionally deactivated in the visualisation.

- Time-dependent analysis for absolute displacements
- Displacement differentials and displacement speeds
- Cross-section related analyses
- Tunnel advance related analyses with constant measurement interval or time difference with respect to the zero measurement (lines of influence, ratios of individual displacement components)
- Analysis with stereographic projection
- Numerical and graphical output of the total deformation including deformation speeds
- Computation of the shotcrete load in accordance with the flow rate method

Setting-out

- Automatic computation of profile-related points, taking into account offsets
- Computation of general profile-related points in the project system and transfer to the total station via GSI interface
- Setting-out functions for conventional break-out (laser off-sets)
- Automatic setting-out of points on the excavation face using the TALOS motor laser system
- Automatic (iterative) setting-out of points of intersection (e.g. intersection of 2 tunnel cross sections) with the use of reflector-free total stations
- Automatic setting-out of pipe umbrellas
- Automatic online setting-out of block gaps, elevations, profiles, drill starting point, etc.
- Tunnel vault shutter setting-out based on the block partition plan
The following other data sheets are associated with this data sheet:

**Services:**
- Network and Control Surveys
- Tunnel heading surveys
- Construction Surveying and Setting Out
- Optical 3D-Deformation Monitoring
- Gyroscopic survey using the Gyromat 2000/3000
- Settlement Levelling
- Profile Checks

**Systems:**
- TALOS III Motor Laser System
- TAUROS TBM Guidance System
- GeoRobot - Automatic 3D-Deformation Monitoring System
- KRIOS Online Setting-Out and Profile Measurement System
Evaluation examples - Optical 3D-displacement monitoring

Lateral displacement versus time - all points of a cross section

Diagram of displacement vectors in a cross-section
Spheric projection of the vector orientation - all points of a cross-section

Convergency between several points in a cross-section versus time
### Speed of lateral displacement versus time - all points of a cross-section

<table>
<thead>
<tr>
<th>Date</th>
<th>Time Axis</th>
<th>Excavation Progress</th>
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</thead>
<tbody>
<tr>
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<tr>
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<td>2</td>
</tr>
<tr>
<td>3/3</td>
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<td>3</td>
</tr>
</tbody>
</table>

**Graph Note:**
- Speed (mm/day)
- Time Axis
- Excavation Progress

![Graph](image)

### Absolute lateral displacement - one certain point in different cross-sections

<table>
<thead>
<tr>
<th>Date</th>
<th>Chainage of Measuring Sections</th>
<th>Advance of Top-Heading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1</td>
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<td>1</td>
</tr>
<tr>
<td>2/2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3/3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

**Graph Note:**
- Absolute displacement of the point in the particular cross-section (mm)
- Chainage of Measuring Sections
- Advance of Top-Heading
- Date

![Graph](image)
Settlement of a certain point in different cross sections at a certain date (deflection lines)

Settlement of a certain point in different cross sections at a certain time difference related to the zero-reading
Differences of lateral displacement between two certain points in different cross-sections at a certain date (deflection lines)

Relation between longitudinal and lateral displacement of a certain point in different cross sections at certain time differences related to the zero-reading